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The adoption of PV in the Netherlands: A statistical analysis of adoption factors

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ABSTRACT

In this paper we studied factors behind the adoption and non-adoption of solar PV in the Netherlands. The main purpose of this paper was to gain insight in and to understand the adoption of PV in the Netherlands from a user perspective. In our analysis, the influence of the following four factors is studied: the perceived relative advantage of the technology, the complexity of the innovation, social influence, and knowledge of grants and costs. For each of the factors, different proxies are being used in an attempt to study individual components. The influence of the four adoption factors are studied for 4 groups: voluntary adopters, involuntary adopters (people who bought a house equipped with solar PV), potential adopters and rejecters. In this research, we used descriptive analyses and logistic regression analyses.

We show that the cost of a PV system is an important element behind the adoption and non-adoption of PV in the Netherlands. For adopters, the costs of adoption are considered affordable whereas for non-adopters they are viewed as being too high. The differences have to do with adopters valuing the benefits more than non-adopters. This shows that adoption depends on attribute perceptions.

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1. Introduction

Although there have been ongoing debates – inside and outside the scientific community – about the reality of a changing climate, the Intergovernmental Panel on Climate Change [1] clearly stated in September 2013 that warming in the climate system is unequivocal, human influence on the climate system is clear, and that the continued emissions of greenhouse gasses (GHG) will cause further warming over coming decades. The IPCC's fifth assessment report [1] further stressed that limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. This requires a fundamental transformation of the energy supply system, including the long-term substitution of fossil fuel conversion technologies by low-GHG alternatives such as renewable energy [2]. In a broad sense renewable energy sources refer to hydropower, bioenergy, solar energy, geothermal energy, ocean energy, and wind energy [3]. Of these sources, solar energy (CSP—concentrated solar power and PV—photovoltaic) is by far the largest followed by wind and ocean energy [4]. Fischedick et al. [5] report that the technical potential of renewable energy as a whole is at least 2.6 times as large as the 2007 total primary energy demand in all regions of the world. He further reports that the long-term percentage contribution of some individual sources to climate change mitigation may be limited by the available technical potential if deep reductions in GHG emissions are sought (e.g. hydropower, bioenergy and ocean energy), while even sources with seemingly higher technical potentials (e.g. solar, wind) will be constrained in certain regions [5]. However, an estimation of the potential (resource, technical, economic, market) of these individual renewables is a difficult task due to the challenges of unifying assumptions for all geographic areas, technologies, politics, human behavior, etc. [2,6]. On a global scale some studies are available that assess the potential of renewable energy sources [6–18]. The outcomes of these studies show that solar energy has a large potential (as per unit of area the output is relatively high) that allows it to become one of the main sources of renewable energy in the long-term future. Despite the large technical potential of PV compared to other renewable energy sources, the total global capacity for PV – 139 GW worldwide in 2013 [19] – is rather low, compared to other renewable energy sources as hydropower or wind [3]. This raises the question why solar PV did not diffuse more. It is believed that the answer to this question has to do with the multiplicity of human valuation. In this paper we focus on the multiplicity of human valuation by examining the reasons for adoption and non-adoption of solar PV in the Netherlands for a sample of 817 households. In our analysis, the influence of the following four factors is studied: perceived relative advantage of the technology, perceived complexity as a negative factor, social influence and knowledge of grants and costs. For each of the variables, different proxies are being used in an attempt to study individual components. The influence of the four adoption factors are studied for 4 groups: voluntary adopters, involuntary adopters (people who bought a house equipped with solar PV), rejecters and potential adopters.

This paper tests theoretical propositions about adoption variables for the case of solar PV in the Netherlands and offers a novel contribution to the literature through the use of a segmentation model. The propositions about adoption variables are based on a review of the literature on adoption of innovation.

The structure of this paper is as follows. Section 2 offers a discussion of the theoretical models of technology acceptance and innovation diffusion (adoption). After describing the theoretical propositions from the innovation diffusion and adoption literature, we examine the empirical literate on adoption of solar PV. This is done in Section 3. Section 4 presents the research data and the segmentation model that is used in the empirical investigation. Section 5 presents the results of our empirical analysis and analyses the implications of the results for PV stimulation policies. The final section describes how our findings compare to those of others and offers a theoretical reflection.

2. Theoretical background

The characteristics of an innovation generally affect the likelihood and speed of its diffusion [20,21]. Ostlund [22] applied diffusion theory to two new consumer products and discriminate buyers from nonbuyers using the personal characteristics of respondents and their perceptions of each new product. In both studies perceptual variables are found far more successful as predictors of the purchase outcome than respondent personal characteristics [22]. Similar findings are reported by Labay and Kinnear [23], who examines PV within an adoption and diffusion of innovation frameworks in the State of Maine. Relative advantage is indicated as an important characteristic which refer to the "degree to which an innovation is perceived as superior to ideas it supersedes (both economic and noneconomic considerations)" [22 p. 24]. The greater this characteristic is, the faster the rate of adoption will be [22,24]. Not all users, of course, perceive the same levels of relative advantage at the same time. Before elaborating on this, we will first elaborate on different categories of characteristics that influence the adoption and/or diffusion of an innovation. Kemp and Schot [25] discussed the determinants of adoption decision with respect to environmental technologies. They divided the adoption determinants into three categories: (1) the system of information transfer, (2) the characteristics of the technology (economic and technical) and (3) the characteristics of the adopter environment. The last category is further divided into environmental policy, price and cost structure, availability and costs of complementary techniques, age of existing consumer goods, competiveness, environmental awareness and attitude, social pressure, availability of financial resources, and resistance to change and acceptation. The importance of these factors is different for each technique and in the time [25]. The proposed categories focuses strongly on the adoption environment and the characteristics of the technology in question, however the characteristics of the individual is missing. Therefore, we introduce the work of Straub [26], who identified three categories of characteristics. Like the categories of Kemp and Schot, Straub focuses on the technological characteristics and contextual characteristics (corresponds to Kemp's characteristics of the adopter environment), but instead of taking the system of information into account, he added a category of individuals who perceived a technology in different ways and thus are more or less inclined to adopt new technologies. Straub [26] described the categories as follow. *Individual characteristics* are individual differences, state- or trait-based characteristics that predispose a person to seek out or shun change. *Innovation characteristics* are specific to the particular innovation, how easy an innovation is to use, how the use of an innovation is compatible with the lifestyle of an individual. Lastly, *contextual characteristics* make up the environment and surroundings of an individual during the adoption process [26].

However, every particular characteristic (e.g. relative advantage) can play several roles and thus occupy multiple positions in the system. We expect that a certain characteristic contains values, beliefs and needs which are even more likely stretched across different categories. Perceived characteristics are important because they show that potential adopters base their opinions of an innovation on a variety of characteristics, not just innovation characteristics. Therefore, we should try to think about how users

will perceive their innovations in terms of all of the three categories, and not focus exclusively on the technical superiority of an innovation.

The most commonly used framework in the area of adoption and diffusion is Rogers' classical "Diffusion of Innovations" framework [24], rooted mainly in the domains of sociology and social communication. For Rogers diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" [24 p. 5]. Thus he organizes the diffusion process into four primary elements that influence the spread of a new idea: the innovation itself, communication channels, time, and a social system.

Rogers takes a social constructivist ontological view in claiming that it is the perceptions of actors that matter from the point of view of adoption and rejection. He also draws attention to the system of communication. He focuses on the human actors participating in the process, but instead of seeing them as "key players" for observed outcomes, he examines them as categories of individuals who perceive technologies in different ways and thus are more or less inclined to adopt new technologies.

Roger's theory [24] provides a useful tool that consists of five stages: knowledge, persuasion, decision, implementation, and confirmation. Each stage consists of different behaviors that are subject to different influences. This research focused on the persuasion stage of the diffusion process, this is when an individual forms a positive or negative attitude towards the innovation. The persuasion stage is crucial for an individual to be committed to adopt or reject an innovation. A key determinant of diffusion in this phase is the five perceived components of innovations: relative advantage, compatibility, complexity, trialability and observability (see Table 1 for definition of perceived attributes). The innovations that are perceived as having greater relative advantage, compatibility, trialability, observability and less complexity will be adopted more quickly and easily than other innovations [24].

The theory has been applied and adapted in numerous ways to model the diffusion of a range of innovations, for example agricultural methods, medical practice, IT solutions, educational innovations, and the use of solar power systems. Several similarities are found in these studies, for example, that technical compatibility, technical complexity, and relative advantage (perceived need) are important antecedents to the adoption of innovations and that innovations tend to diffuse following an *S*-Curve of adoption [21,27,28].

While Rogers's concern, for the most part, is about the specific type of adoption environment, Davis's emphasis is on a specific type of innovation. According to Davis Technology Acceptance Model (TAM) [29], one's actual use of a technology system is influenced directly or indirectly by the user's behavioral intentions, attitude, perceived usefulness of the system, and perceived ease of the system. He also proposes that external factors affect intention and actual use through mediated effects on perceived usefulness and perceived ease of use. Davis defines *perceived usefulness* as "the degree to which a person believes that using a particular system would enhance his or her job performance" and *perceived ease* of use as "the degree to which a person believes that using a particular system would be free from effort" [29]. TAM is an adaptation of the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen [30] and is extended to TAM2 by including subjective norm as an additional determinant of intention in the case of mandatory settings [31]. Table 2 gives an overview of the key concepts used in the work of Davis.

TAM can be used in a wide variety of ways, but it is mainly used to explain factors that influence the use of information systems. A large number of studies have been conducted using the original TAM or an extended version of it. These studies confirmed the strong relationship (convergent and discriminant validity) between and among the two concepts and the significance of them in predicting system usage, however, little is understood about different user responses to information systems [32].

Roger's and Davis both focus on the adoption stage, but the difference between the two theories is that Rogers describes this from a general perspective whereas Davis has the individual user as a starting point. More in detail, Rogers helps to explain and analyze how a new idea, object, or practice is communicated and accepted by others while Davis' model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it. In order to provide a unified theoretical basis from which to facilitate research on adoption and diffusion, the Unified Theory of Acceptance and Use of Technology (UTAUT) was proposed and validated by Venkatesh [33]. The model is a synthesis of eight existing models of technology acceptance, including the work of Rogers' and Davis'. The model integrates elements from Theory of Reasoned Action (TRA), Motivational Model (MM), Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM), a combined Theory of Planned Behaviour/Technology Acceptance Model (C-TPB-TAM), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), and Social Cognition Theory (SCT).

The unification of these models provides UTAUT with seven constructs. The authors theorized that four constructs – performance expectancy, effort expectancy, social influence, and facilitating

Table 1
Roger's five perceived components of innovations [4].

Attributes	Definition
Relative advantage	The degree to which an innovation is perceived as better than the idea or technology it supersedes by a particular group of users, measured in terms that matter to those users, like economic advantage, social prestige, convenience, or satisfaction
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and the needs of potential adopters
Complexity	The perceived difficulty to understand and use the innovation
Trialability	The degree to which the adoption of an innovation is experimented without making long-term commitments or incurring significant costs
Observability	The degree to which the results of an innovation are visible to others

Table 2
Key concepts of Davis's Technology Acceptance Model.

Key concepts	Definition
Perceived usefulness	The degree to which a person believes that using a particular system would enhance his or her job performance [10]
Perceived ease	The degree to which a person believes that using a particular system would be free from effort [10]
Subjective norm	The person's perception that most people who are important to him think he should or should not perform the behaviour in question [11]

Table 3
Key determinants of innovation adoption according to the unified theory of acceptance and use of technology [33].

Key determinant	Definition
Performance expectancy	The degree to which an individual believes that using the system will help him or her to attain gains in job performance
Effort expectancy	The degree of ease associated with the use of the system[a]
Social influence	The degree to which an individual perceives that important others believes he or she should use the new system
Facilitating conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system

[a] In the case of solar PV, there is no effort connect to use. The effort consists of obtaining relevant information about the products and applying for a grant.

conditions – play a significant role as direct determinants of user acceptance and usage behavior (see Table 3 for definition of the concepts). Attitude toward using technology, self-efficacy, and anxiety are theorized not to be direct determinants of intention, mainly because they were found not to be significant in the presence of effort expectancy. The theory also assumes that the effect of core constructs is moderated by gender, age, experience, and voluntariness of use [33].

A systematic review of citations of UTAUT's originating article concludes that the UTAUT provides a useful tool by which to evaluate the potential for success of new technology initiation and helps identify factors likely to influence adoption of technology [34]. Although the model was constructed to explain user intentions to use an information system and subsequent usage behavior, the constructs and variables from the theory are very well applicable to explain the adoption of PV in the residential area. Therefore, we have part of this framework taken, as well as some concepts from the framework of Kemp and Schot, Rogers and Davis, as a starting point in our analysis. Before elaborating on this, an overview of solar energy diffusion studies is given.

3. State-of-the-art in solar energy diffusion studies

Although many studies consider the diffusion of solar energy technology, few studies among them are dealing with solar energy from a consumer behavior perspective. The following studies are contextually related and show some interesting issues in this area.

Thomas Sparrow is the first researcher who focused primary on the purchase decision of solar energy. He considered various socio-economic factors involved in the adoption of solar-energy technologies in a study of 45 owners–users of solar custom homes located throughout the United States in 1977. In his study, Sparrow emphasized that there are region-specific differences in consumer attitudes as well as in factors of importance for those adopting solar energy systems in different geographical regions.

However, the small and geographically diverse sample presents difficulties [23]. Another study conducted in the United States was undertaken by Cesta and Decker [35] to determine and measure the attitudes of the public, including consumers. A two-stage Delphi research study identified some factors that may either inhibit or stimulate solar energy adoption and commercialization. The following factors were found to be important: product cost, lack of product knowledge, lack of governmental support, and public concern over the energy crisis. Cesta and Decker also found that governmental and business actions could help to initiate greater solar energy use and developmental efforts [35].

Several researchers used Rogers' diffusion of innovation theory as their theoretical framework. Labay and Kinnear [23] used the theory to examine the purchase decision process of residential solar energy systems in one geographical region, the State of Maine. Multivariate nominal scale analysis is used to develop classification models based on both attribute perceptions of solar energy systems and demographic characteristics. They discovered that attribute perception data afford somewhat greater classification ability than demographic data. An important aspect in the work of Labay and Kinnear is the inclusion of knowledgeable non adopters as a group worthy of attention, in addition to adopters and unaware non adopters. They argued that the knowledgeable non adopters evaluated the product and economic factors (e.g. quality of the system and payback period) higher [23], which indicate the potential for adoption. Kaplan' [36] research also used Rogers' diffusion of innovation theory to investigate why utilities not adopt solar power and what might help encourage their interest. The inclusion of motivation, experience and familiarity (e.g. whether the household has previously installed a similar technology, such as solar heating) are important variants which can influences the interest in PV. These findings have significant implications for commercialization efforts, as well as for management of utility operations. Kaplan emphasized that through small wins, experimentation, and groping along, solar power can be diffused far more effectively and with far greater ultimate success than is expected through the conventional wisdom of large-scale research and development [36]. The study conducted by Faiers and Neame [37] also utilized Rogers' theory to investigates householder (using householders in central England as case) attitudes towards characteristics of solar systems and identifies some of the barriers to adoption. A group of 'early adopters', and a group of assumed 'early majority' adopters of solar power were surveyed and the results show that overall, although the 'early majority' demonstrate a positive perception of the environmental characteristics of solar power, its financial, economic and aesthetic characteristics are limiting adoption [37]. In other words, the actual cost of an innovation is relatively unimportant; what matters is what it is worth to the adopters as individuals. Jager [38] studied factors that lead to a faster diffusion of PV in society from a behavioral perspective. He discussed different consumer motives within a framework of underlying needs and the time sensitivity of various outcomes. Financial support and general problem awareness are found to be critical motives[1] in the city of Groningen, but the positive effects of information meetings, technical support meetings and social networks are also identified. In terms of the factors affecting the speed and degree of diffusion [24], these meetings reduced the complexity of the decision problem as experienced by the buyers [38].

Research that considers the behavioral responses to PV influenced by the broader socio-technical system is conducted by Keirstead [39]. He used PV households in the UK as case to investigate whether the use of PV could have a double divided effect, providing renewable energy as well as any changes in energy use. This research showed that the installation of PV encouraged households to reduce their overall electricity consumption by approximately 6% and shift demand to times of peak generation [39]. Palm and Tengvard [40] also studied the adoption of PV from a broader sociotechnical perspective and embedded their work within the transition literature. Analysis of material

[1] These motives can also be seen as facilitating factors.

from in-depth interviews with members of twenty Swedish households reveals that environmental concerns are the main motive for adopting PVs or microwind turbines. Other indicated motives were an ecologically aware lifestyles, a symbolic investment (provide a way to display environmental consciousness) a protest against “the system”, with its large dominant companies, or a step toward self-sufficiency. Some households reject these installations because of financial considerations, respect for neighbors who might object, and/or difficulties finding an appropriate site [40].

This state-of-the-art review showed that adopting PV requires more than simply interpreting its technical characteristics, the technology must also be compatible with the desires and frame for evaluation of the household. Therefore, attribute perception rather than objective date could significantly increase the insight in and the understanding of the adoption of PV, which is well beyond the state of the art.

4. Research method

Authors have made distinctions between studies of the diffusion and adoption of innovations. Although a certain degree of overlap between those concepts may exist, adoption analysis often take characteristics (individual, innovation as well as contextual) into account while diffusion analysis does not, or only to a very small extent. This study focused on the adoption of PV in Dutch households and examined properties that enhance or hinder this process by using perceived characteristics. In examining the adoption of PV, we focus on the explanatory power of some the key concepts introduced by Venkatesh, the five perceived components introduced by Rogers, the concepts introduced by Davis and some sub categories of the work of Kemp and Schot. The key concepts from the different models are taken into account to help gauge people’s perceptions of PV, so as to better anticipate their adoption processes.

The analysis is conducted via an internet questionnaire regarding the Dutch citizens. The majority of the questions were multiple choice questions with a few open questions. The data gathering took place in September 2011. A total of 817 people out of 1371 have responded to the questionnaire, which is a response rate of 60%. This is a representative sample over the Dutch population (21–65 year) regarding gender, age distribution, level of education and spatial distribution in the Netherlands (see Appendix A). In order to classify the respondents, we used a segmentation model which is introduced by Vasseur and Kemp [41]. Four relatively homogeneous groups of technological users are determined based on their adoption or rejection of a specific technological innovation, in particular solar PV. The four groups are voluntary adopters, involuntary adopters (people who bought a house equipped with solar PV), potential adopters and rejecters. This segmentation allows us to answer the question whether adopters and non-adopters consider the same or different attributes for their decisions. These insights can provide insight into how the government’s policy or service can align the needs of the customer (citizen) as well as how suppliers of this technology can optimize their product based on these wishes. Especially in the domain of adoption of sustainable energy sources there is little scientific research from a user perspective. This urges the need for such research in which the adoption is studied from a user perspective.

The questionnaire consists of a variety of questions. We started with questions about their impression on their own lifestyle in the view of sustainability. A description of sustainable development was given to all respondents through an information button to ensure everybody had the same information. We also asked the respondents whether they think that the implementation of PV should be stimulated, for example by providing subsidies, and how they think that actors in the field should take the lead in general. Furthermore, we asked to rank the importance of different characteristics of a PV system in deciding to adopt PV by importance. But there is also a section which aimed to find out which aspects non-adopters of PV find important in order to observe the barriers for and during adopting a PV system. We asked the respondents who did not have a PV system themselves to indicate their agreement and disagreement of different statements based on possible motives for purchasing a PV system. On the other hand we also investigate the different motives adopter of PV had for purchasing a PV system.

Descriptive analyses were conducted to analyze the perception of a representative sample of the Dutch population regarding solar energy, e.g. motives behind the adoption process. Although there are many ways to analyze the perception of people, in this paper we used an indicator-based approach. These respondents were provided with a questionnaire with different items, these items were indicators for analyzing the adoption process of PV. To compare the differences, the four groups who have been formulated according to their decision to adopt or not adopt a PV system, are also studied statistically. We use logistic regression analysis to determine the predicting factors for adoption or not. We also categorized and quantified responses to the open-ended questions on positive and negative expectations and experiences.

5. Results

5.1. Sample

Table 4 shows the findings regarding demographic characteristics obtained from the descriptive analysis. Comparing the adopters with the representative sample of the Dutch population, we see that the adopters are in general higher in income, younger and more highly educated than the general population. Comparing the adopters with the non-adopters, a few differences are apparent. The level of income does not appear remarkable similar which corresponds our expectations. We expected PV adopters to have higher incomes than non-adopters as PV systems are very expensive in purchase. Of the adopters, 31.6% have an income between €22,500 and €36,000 and 13.2% have an income above €36,000. For non-adopters these numbers are different, the majority have an income below €22,500 (47.0%) and only 5.6% have an income

Table 4
Demographic findings.

Income	Response (%)	Adopters (%)	Non-adopters (%)
< 22,500	46.3	31.6	47.0
22,500–36,000	25	31.6	24.6
> 36,000	6	13.2	5.6
Unknown	22.8	23.7	22.7
Age distribution			
21–24	4	5.2	4.0
25–29	9	2.6	13.5
30–34	9	10.5	9.1
35–39	9	15.8	8.7
40–44	13	13.2	13.1
45–49	14	15.8	14.4
50–54	14	13.2	13.5
55–59	15	15.8	15.1
60–65	13	7.9	11.0
Level of education			
Low (primary, vmbo, lbo)	28	15.7	28.2
Middle (havo, vwo, mbo)	41	39.5	40.6
High (hbo, university)	32	44.7	31.2

above €36,000. In age, the adopters and non-adopters appear quite similar in the Netherlands, but the adopter seems a little bit younger, however, this trend is not strong. Looking at education, the adopters appear more concentrated around the category high level of education while non-adopters have a middle level of education. Revealing the diffusion of innovation theory which suggests that the adopters might be "innovators" of PV technology and if so, they are likely to be well-educated [24].

These findings are in line with the results of Labay and Kinnear [23], who conclude that adopters of PV are younger, more highly educated, higher in income, earlier in the family life cycle, and higher in occupational status than the general population. However, their observation that adopters are younger is not confirmed by the research conducted by Jager [38]. The research of Keirstead [39] indicated that PV adopters do not represent an even mix of ages, instead favoring older ages. This significant difference from the national statistics may be explained by characteristics associated with older age such as higher income and owning one's own home [39].

Of the respondents in our sample, 38 respondents adopted a PV system, 18 respondents voluntary and 20 respondents involuntary. The latter group could also decide the adoption quasi-voluntary which in this research is also labeled as involuntary. Of the remaining 779 respondents, 293 (37.6%) are in the orienting phase or will adopt a system when the majority adopt a system and/or when they see the usefulness of it. These respondents together are called the potential adopters. The majority of the non-adopters are rejecters, namely 62.4% (486 respondents).

Of the 38 respondents that adopted a PV system, a total of 25 reported having an own house and 11 reported having a rented house,[2] the remaining 2 reported others. There is not a specific type of house, but free standing house, semi-detached house and terraced houses are in favor. Given the selected technology in this study, one physical barrier can be identified: if a household is situated in a stacked building (e.g. apartment) it is assumed that they often do not consider the option of solar PV panels individually. The majority of the voluntary adopters live in a town. For an overview, see Table 5.

Looking at the non-adopters, 478 respondents reported that they are home-owner which could consider the option for PV panels individually. Remarkable, only 16 out of 779 respondents (2.1%) live in the countryside and do not have the intention to adopt a PV system.

Table 5
Crosstab for the number of respondents having a PV system or not and housing conditions.

	Adopter of PV		Non-adopters of PV	
	Voluntary adopters	Involuntary adopters	Potential adopters	Rejecters
Frequency	18	20	293	486
Home-owner				
I	13	12	228	250
Public rental	3	6	34	181
Private rental	1	1	17	43
Housing type				
detached	6	1	45	30
middle of a row	6	9	112	234
semi-detached	3	7	63	59
apartment	1	3	49	122
farm	0	0	6	1
others	2	0	18	40
Housing situated				
city	6	10	157	295
town	12	10	125	175
Countryside	0	0	11	16

5.2. Thresholds and benefits

In this section we investigate the different thresholds and benefits (non) adopters of PV had to adopt a PV system. We asked them to indicate possible thresholds and motives in deciding to adopt a PV system by importance, maximum three answers were possible. We also asked the non-adopters to indicate under which condition they would adopt a system and which aspects have triggered the adopters in their decision. The latter was asked in the form of an open-ended question.

Table 6 shows the motives adopters had to adopt a PV system, ranked from important to unimportant. The most important motives to adopt PV are saving electricity costs (66.7%), the costs of a PV system (50%) and the possibility to be self-sufficient (33.3%). The fact that with the use of a PV system one has less environmental impact has also been an important reason for people to adopt. The respondents also indicated that the innovativeness of a system, the visual aspect and the ease to install a system are less important motives for people to adopt a system. These results are not in line with the research of Jager [38] and Palm and Tengvard [40], who rated the contribution to a better natural environment as the most important motive for adoption. Palm and Tengvard [40] also indicated the symbolic investment as an important aspect which is not in line with our findings.

House improvements and subsidies were the decisive factors for adoption, repeated by respectively 5 and 4 respondents, followed by stories from the media and the convenience of having a PV system, both 2 respondents. It should be noted that house improvements is a broad concept. It contains the increased value of a home but also the decorative value of it. Since the questionnaire did not contain a question about the relative importance of these aspects it is impossible to determine which are perceived as more important.

Apart from the motives and decisive factors, we also asked the voluntary adopters how they funded their PV systems. The results show us that the vast majority paid the PV system with their savings (66.7) and some with a mortgage (16.7). Remarkable, one respondent reported that the system was paid by an increase in rent of the building.

Table 7 shows the thresholds for non-adopters to adopt a PV system, ranked from important to unimportant. The results show us that the vast majority found the high investment cost of PV the most important aspect (58.3%). This typically is a financial threshold. Many of these respondents mentioned that the financial arguments are the specific conditions which would be changed before they will consider the purchase of system. More in particular, 47.8% indicated that the investment has to drop significantly (ranked as the most important one) and 31.3% of the respondents would also adopt a system if there is an attractive subsidy program.

The fear of energy yield (15.7%) and gaining the promised efficiencies (15.1%) is also indicated as a reason to not adopt PV. A reduction in the payback period (maximum period of 5 years) is indicated as specific condition for making the step to adopt PV.

For many of the respondents, the physical non-accessibility and non-ownership of the house keeps them from adopting PV: 224 respondents indicated to not be a home-owner, 117 people is living in an apartment or flat and 52 respondents have plans to move. Technical complexity does not appear to be an important

[2] The domestic sector in the Netherlands is divided over three types of ownership. Each represents a different type of decision maker with respect to the purchase of PV: (1) private rental sector in which private landlords make the investment decision; (2) public rental sector in which housing associations make the investment decision; (3) owner-occupied sector in which the residents themselves are the decision makers.

Table 6
Motives and decisive factors to adopt a PV system, ranked from important to unimportant.

Motives	Percentage (1st, 2nd or 3rd)	Decisive factors	Number of respondents
Savings on electricity bill	66.7	House improvement	5
Costs efficient system	50	Subsidy programme	4
Self-sufficient	33.3	Media	2
Less environmental impact	27.8	Convenience	2
Quality of the system	22.2	In combination with boiler	2
Innovative system	11.1	Cheaper in term of energy consumption	1
Visual representation	5.6	Interest and expertise	1
Easy to install	5.6	Others	1

Table 7
Thresholds/barriers for making the step to adopt a PV system and the specific conditions to adopt a PV system, ranked from important to unimportant.

Thresholds/barriers	Percentage (1st, 2nd or 3rd)	Specific conditions	Percentage (1st or 2nd)
Investment is too high	58.3	If the investment drops significantly	47.8
I am not a home-owner	28.8	If the payback is 5 years max	36.3
Energy yield is too low	15.7	If there is an attractive subsidy program	31.3
Fear of gaining promised efficiency	15.1	Under no circumstances	10.9
I live in an apartment	15.0	If the system is nicely integrated	9.6
Not interested	12.2	If the system can easily be mounted	6.7
Difficult to install	9.6	If the quality of the system improve	5.9
Visual representation	7.7		
Fear of subsidy adjustments	7.1		
Plans to move	6.7		

Table 8
Actors and instruments/aspects by promoting the implementation of PV, ranked in terms of importance as stated by actors.

Actors	Percentage (1st, 2nd or 3rd)	Instruments/aspects	Percentage (1st or 2nd)
National government	72.8	Via tax benefit	52.8
Municipality	40.1	By exchange of information	31.6
Gas and electricity companies	40.0	By stimulation of innovations	25.7
European Union	38.1	By introducing a clear vision for the future which show the effect of certain choices	19.4
Provincial government	22.1	Via legislation and regulation	19.1
Me	21.0	By limiting restrictive legislation	11.8
Business	16.0	By introducing clear goals	9.3
Science	7.1	Through contracts with citizens, government and industry	9.3
Trade union	1.5	Others, e.g. lease construction, technology	3.4
Others, e.g. landlord, housing corporation	1.5	By addressing people with their responsibility	3.0

threshold. Only a small amount of non-adopters claim that the system is too difficult to install. Also the attractiveness of the system is not indicated as an important threshold, even a nicely integrated system is not ranked as a very important condition during the adoption process. Finally, some respondents mentioned that they are not interested in adopting a system and will not adopt a system whether there are ideal or specific conduction available.

Apart from the thresholds above, we asked the respondents whether they think that the implementation of PV should be stimulated or not and how they think that actors in the field should take the lead in general, not per leader. In Table 8 the importance of the different actors and aspects/instruments are ranked from important to unimportant.

Of the respondents in our sample, 90.5% indicated that PV should be stimulated. It was also explored to what extent actors in the field should play a role in the stimulation of solar energy. The government is seen as the actor who should take the lead (72.8%), followed at a large distance by the municipality, gas and electricity companies and the European Union. Surprisingly, 155 respondents, 21.0%, reported that they see themselves as the promising actor who should take the lead. This latter implies that for a reasonable group of people other actors has no or minimal impact on their decision to adopt a system.

Thus, different actors are expected to contribute to the implementation of PV, but the government is seen to be the most important actor who can make a difference by a vast majority of the respondents. According to the majority of the respondents, the government should create tax benefit (52.8%), provide subsidies (legislation and regulation) (19.1%), develop a vision (19.4%) and set goals (9.3%). The reason behind this, the implementation of PV is a long term trajectory depending on an enabling environment and coordinated action. Furthermore, the answers indicate that more information[3] (31.6%) is needed on solar energy. Although, public information on the ins and outs of PV seems to be important it will be not sufficient to stimulate the diffusion of PV. Coming back to the vision and goals, we have seen in previous

[3] Information meetings can play a relevant role in the adoption process of people, providing information about the procedure for submitting a request or reducing their perception of the technical installation.

Table 9
The influence of relative advantage as a predictor for adoption of solar PV.

Relative advantage—*The degree to which an innovation is perceived as better than relevant alternatives now and in the future*
Logistic regression analysis (0 = rejecters; 1 = voluntary adopters)

Predictors	B	Sig.	Exp(B)
The investment of a system is affordable	3.438*	.000	31.118
Solar energy is the best available technology to be self-sufficient	−2.477**	.039	.084
Increasing prices of oil and gas will support the use of solar energy	−1.353	.299	.258
Solar energy is considered as the most sustainable energy source	.863	.418	2.369
Solar energy will become cheaper than oil and gas	0.058	.957	1.060
The environmental benefits of solar energy are positive	19.630	.998	3.351E8

*** Significant at the 0.1 level.
* Significant at the 0.01 level.
** Significant at the 0.05 level.

work that this is a weak point in the implementation trajectory of PV and thus is definitely an area of concern.

5.3. *Our explanatory variables*

Some key concepts from the different models are taken into account to help gauge people's perceptions of PV. From the work of Rogers, we will use the relative advantage and complexity as Rogers sees them as the two strongest predictors of successful adoption rates out of the five attributes as well as out of the diffusion literature as a whole [24]. The concept complexity has substantial similarity among the construct definitions and measurement scales of perceived ease of use and effort expectancy (see Tables 1–3). The social influence towards the innovation and knowledge of grants and costs are included in the analysis as explanatory variables.

5.3.1. *Relative advantage*

The relative advantage refers to the perceived superiority of the innovation as compared with the existing values practices [24], in other words the degree that an innovation appears to be better than its preceding idea, practice, or object. An example of this is the adoption of mobile phones; potential users see the characteristics of mobility as an advantage thus the technology is perceived to be better than traditional telephones. Rogers theorizes that relative advantage is one of the strongest predictors of adoption rates to addresses the reduction of uncertainty. He argues that levels of uncertainty decrease when participants weight the benefits of a technology against the costs of adoption and perceive a low risk and high benefit [24]. Similar findings are reported by Labay and Kinnear [23], in their PV research relative advantage is indicated as an important characteristic (both economic and noneconomic considerations), the greater this characteristic is, the faster the rate of adoption will be [22,24]. Not all users, of course, perceive the same levels of relative advantage at the same time. Relative advantage is not something that can easily be measured. Different aspects are being weighed and compared. In the case of solar PV, the following aspects are important: the costs of adoption, the price of fossil fuels (which determine the economic value of solar power against fossil fuel alternatives), the esthetics of a roof with solar PV panels, and the wish to be environmentally responsible and to be seen as such. Rather than lumping these aspects together, we break down relative advantage in a number of components, as this will help us to determine which aspects are the most important ones. Our proxies are the expectation that solar energy will become cheaper than oil and gas (1), the expectation of increasing prices of oil and gas (2), the view that solar energy is the best available technology to be self-sufficient (3), the view that solar energy is the most sustainable energy source (4), the view that solar energy is environmentally benign (5) and the view that the investment of a system is affordable (6).

In this part we are interested in the factors that influence whether a respondent adopt a PV system. The outcome (response) variable is binary (0/1); reject or adopt. The predictor variables of interest are factors which refer to the (relative) advantage of having a PV system. The factors used in this analysis are given in Table 9. We performed a Hosmer–Lemeshow test of goodness of fit. This test is similar to a Chi Square test, and indicates the extent to which the model provides a better fit than a null model with no predictors, or, in a different interpretation, how well the model fits the data, as in log-linear modelling. If chi-square goodness of fit is not significant, then the model has adequate fit. By the same token, if the test is significant, the model does not adequately fit the data. The Hosmer–Lemeshow test for the representative sample of Dutch population is not significant (Chi^2 3.446; sig. 0.632) which indicates adequate fit (model prediction that is not significantly different from observed values) and therefore our model can be used to analyze whether there is an influence on the adoption of PV.

In this research we used binominal logistic regression analysis because we want to be able to predict the presence or absence of an item or characteristic based on values of a set of predictor variables. This analysis is similar to a linear regression model but is suited to models where the dependent variable is dichotomous, as is the case in this research. In this research the binominal logistic regression analysis was conducted by using the relevant relative advantage concepts as the predictors of adoption or rejection the technology. In this analysis respondents are coded 1 for voluntary adopters and 0 for rejecters, and predictors coded 1 for agree with the statement and 0 for not agree with the statement. The coefficient is given in the column labeled "B" and the odds ratio is given in the right-most column labeled "Exp(B)".

The results show that the first two items are statistically significantly ($P < 0.05$), the effect on adoption of the other concepts is not significant. The results suggest that *the investment of a system is affordable* is the best predictor for PV adoption (positive significant value of B; $P < 0.01$). The positive value of B indicates that for the statement that the investment of a system is affordable the target group (voluntary adopters) tends to have more of those coded '1' (agree with the statement) than of the code '0' (not agree with the statement), after controlling for the other predictors. Thus, for voluntary adopters the system is affordable but the rejecters see the investment they have to do as an issue for not adopting a system which corresponds with the results of the descriptive analysis. The descriptive analysis tells us that the price of a solar system is indicated as the most important issue

Table 10
The influence of complexity as a predictor for potential adoption of solar PV.

Complexity—*The perceived difficulty to understand and use the innovation*
Logistic regression analysis (0 = rejecters; 1 = potential adopters)

Predictors	B	Sig.	Exp(B)
Enough information is available on solar energy and the possibilities	−.802*	.000	.449
Importance of environmental benefits	1.725**	.002	5.615
The application of a system is easy	.431***	.099	1.539
The subsidy procedure is clear	.251	.352	1.286
Technical knowledge is not a barrier	.190	.433	1.209

* Significant at the 0.01 level.
** Significant at the 0.05 level.
*** Significant at the 0.1 level.

perceived by the respondents[4] (66%). However, the affordability of the system is considered as low by the non-adopters (6.5%) and high by the adopter (60%). The financial advantage adopters have with having PV was also one of the main reasons for adopting which corresponds with our earlier findings (see Section 5.2).

The predictors increasing prices of oil and gas will support the use of solar energy and solar energy will become cheaper than oil and gas[5] are not statistically significant predictors for past adoption. In the table we see that solar energy is the best available technology to be self-sufficient has a statistically significant effect on the prediction of the adoption process (negative significant value of B; $P<0.05$). The negative B indicates that the voluntary adopters tend to have more of those coded '0' than '1' compared to the rejecters. Thus more rejecters than voluntary adopters agreed with this statement which shows that it is a predictor that influences whether a respondent reject a system. A possible explanation for this remarkable finding is that adopters are also more aware of other green technologies, some of which may be preferred over solar PV. However, this cannot be confirmed. The self-sufficiency is an important reason for owning a PV system; the descriptive analysis shows that 83.1% of all the respondents agreed with this statement.

The *environmental benefits of solar energy* do not come out as a predictor for adoption of a system. From this we can conclude that financial aspects play a more important role than the environmental benefits. Other items which relate to the concept of relative advantage are *improvements on the system are necessary* and *the system is profitable*. These items are not asked to all four groups (see Section 4) and therefore it was not possible to include these in this analysis, nevertheless we can still describe these items. 31.8% of the respondents reported that improvements of the system are necessary before they consider adoption, which indicated that it is not the best predictor for adoption. A good predictor for adoption, however not statistically proven, is *the profitability of the system*, 73.1% of the adopters indicated this as important item, which had a big relative advantage during the adoption process.

5.3.2. Complexity

In the previous part we investigated factors that had an influence on the voluntary adoption of a PV system. The results suggest that the financial aspect have an important influence for adopting or not adopting a system. However, we are also interested in factors related to the complexity of a PV system that have an effect on the respondents that are labeled as potential adopters of PV compared to the rejecters (again a binary variable). Complexity is the perceived degree to which an innovation appears difficult to understand and use, and is a subjective perception. Complexity involves both usability (easy or difficult to use) and comprehension (easy or difficult to understand), but the two can be viewed as separate in mind of potential adopters. For instance, one may perceive a technology as simple to understand (online banking) but difficult or inconvenient to use (no internet access), which is why we should take both aspects to provide a full depiction of complexity.

Solar energy, or a PV system, is a complex and abstract concept for which is assumed that people might not recognize what it exactly is and how it can precisely contribute to the reduction of CO_2. We found out that it is difficult to test the generic knowledge of PV as there is a discrepancy between what people say they know and what they actually know. To respond to this, we use some obvious factors related to the complexity of the system to identify their influence: (1) technical knowledge is not a barrier, (2) the subsidy procedure is clear, (3) the application of a system is easy, (4) enough information is available on solar energy and the possibilities, (5) importance of environmental benefits (see Table 10). Respondents are coded '0' for rejecters and '1' for voluntary adopters; predictors coded '0' for not agree with the statement and '1' for agree with the statement.

The results show that the relationship between the complexity items and adoption can be analyzed; the chi-square test is not statistically significant (.661). In the logistic regression analysis, the availability of information had the largest significantly ($P<0.001$) negative influence on the adoption intention. The negative B for the statement *enough information is available on solar energy and the possibilities* indicates that more potential adopters answered that there is not enough information available. Thus, this statement is not a predictor for whether a respondent will adopt a system. Rather it is a predictor which shows that one of the reasons why potential adopters have not adopted a system at the moment is that they lack knowledge about PV. These findings suggest that public information about the possibilities and the procedures may be helpful to those interested in adopting solar PV. However, there is no evidence that such information alone would motivate anyone to buy a system. Similar findings are reported by Kaplan [36] and Jager [38].

Two positive significant predictors for the willingness to adopt are *the importance of environmental benefits* and *the application of a system is easy*. The latter is in contract to the negative predictor of the availability of information and the possibilities of it. However, 47.8% of the non-adopters reported technical knowledge as a barrier which indicates that the provision of technical knowledge would be necessary. But, such information might fall on deaf ears unless its recipients have already been motivated to adopt it

[4] Since the questionnaire did not ask people about the relative importance of the several aspects of this price (purchase, operating costs, maintenance costs, and insurance rates) it is impossible to determine which are perceived as most important.
[5] This aspect is added as a reason for delaying the solar investment.

Table 11
Logistic regression analysis using relevant factors for social influence, an analysis between potential adopters and rejecters.

Social influence—*The degree to which an individual is an independent decision maker, is a social person and feels pressure to adopt the innovation*
Logistic regression analysis (0=rejecters; 1=potential adopters)

Predictors	B	Sig.	Exp(B)
I feel pressure from social environment to purchase solar panels	.178	.724	1.195
I take big decisions dependent of others	−.157	.316	.855
I like to pose myself in service of others	−.098	.894	1.026
I try to be an example for others	.178	.724	1.195

*Significant at the 0.01 level.
**Significant at the 0.05 level.
***Significant at the 0.1 level.

(potential adopters), which confirmed this result (potential adopters (1) agreed more with the statement (1) than rejecters).

While information alone will not change the decision, clear and understandable product information could help raise consumer awareness of environmentally friendly products, in our case a PV system. This could, in turn, increase the purchase of PV because the product is more familiar, the product benefits are more transparent, and the behavior could potentially be more convenient for the consumer. This is in line with the second positive statistically significant item ($P<0.05$) as the *environmental benefits* have a positive influence for potential adopters with respect to rejecters (potential adopters (1) agreed more with the statement (1)). Thus, the importance of environmental benefits of the system is a good predictor in the adoption process.

5.3.3. *Social influence*

The social influence is the degree to which an individual feels pressure from others to adopt an innovation. Such influence may be important or not, depending on whether people are independent decision makers or not. We designed some proxies for social influence and independence of decision-making, which are (1) whether they take big decisions dependent of others, (2) try to be an example for others (3) put themselves in service of others, (4) feel pressure from friends and family to purchase solar panels (see Table 11). We analyzed whether those factors differ between potential adopters of PV and rejecters. It is also interesting to analyze whether the actual adopters were influenced by their social environment or the social nature of a person. In our analysis social influence does not come out as a significant factor. None of the variables used has a significant influence on adoption (Table 11).

For this analysis we coded the respondents with ‘0’ for rejecters and ‘1’ for potential adopters, and predictors coded ‘0’ for not agree with the statement and ‘1’ for agree with the statement. The effect on adoption of all the concepts is not significant, nevertheless, this is also an interesting result. This result indicates that none of the predictors can influence the adoption process, thus rejecters and potential adopters did not answer differently on the different statements.

The descriptive analysis shows that only 2.6% of the potential adopters and 2.5% of the rejecters agreed with this statement. However, it is likely that the individual will adopt a particular attitude when a large portion of an individual's referent social group holds it as well. Additionally, it is also expected that individuals change their opinion under the influence of another who is perceived to be an expert in the matter at hand. Since the questionnaire did not contain a question about the relative importance of these aspects it is impossible to determine which are perceived as more important.

5.3.4. *Knowledge of grants and costs*

To study the influence of knowledge of grants and costs we queried voluntary adopters and rejecters to indicate their agreement of different factors related to their familiarity and knowledge of grants and costs of adoption. Our model is not significant (.208), suggesting that knowledge variables are not strong predictors for adoption. Our proxies for this analysis are the expectation that—the subsidy procedure is clear (1), the view that people are familiar with the costs of solar panels (2), and the view that people are aware of grants. We do find some evidence that knowledge matters (see Table 12).

Table 12
Logistic regression analysis using relevant factors for knowledge of grants and costs, an analysis between potential adopters and rejecters.

Knowledge of grants and costs—*Actors' knowledge of grants for solar PV and the costs of adoption*
Logistic regression analysis (0=rejecters; 1=potential adopters)

Predictors	B	Sig.	Exp(B)
The subsidy procedure is clear	.520*	.000	1.682
Familiar with the costs of solar panels	.351**	.019	1.420
Aware of grants	.253***	.094	1.288

* Significant at the 0.01 level.
** Significant at the 0.05 level.
*** Significant at the 0.1 level.

The results show that all the items related to knowledge of grants and costs have a positive influence on the adoption process (positive significant value of B; $P<0.1$). More in detail, the positive values of B indicates that for the different statements the target group (voluntary adopters) tends to have more of those coded ‘1’ (agree with the statement) than ‘0’ (not agree with the statement). To say it in words, for rejecters, the subsidy procedure is less clear, they are less familiar with the costs of solar panels and less aware of grants. Of these variables, the best predictor for potential adoption of a PV system is that the subsidy procedure is clear, the second predictor is that they are familiar with the cost and also often are aware of grants, third predictor. Provision of public information about the possibilities and the procedures may be helpful to those interested in, however there is no evidence that such information alone would motivate anyone to buy a system.

Looking at the adopters, it was found that six respondents have used a subsidy program and two a stimulation program. For all these respondents (8) the program had a decisive role. Eight out of the 18 have used a program which corresponds with 44.4%. It was also found that 10 respondents installed the system themselves.

6. Discussion and conclusion

In this paper we studied factors behind the adoption and non-adoption of solar PV in the Netherlands. The main purpose of this paper was to gain insight in and to understand the adoption of PV in the Netherlands from a user perspective. In examining the adoption of PV, we examined the explanatory power of some the

key concepts introduced by Venkatesh, the perceived components introduced by Rogers, some concepts introduced by Davis and some sub categories of the work of Kemp and Schot. In our analysis, the influence of the following four factors was studied: the perceived relative advantage and complexity of the innovation, social influence, and knowledge of grants and costs. Different measures were used to investigate the relative importance of those factors and specific elements thereof.

Descriptive analyses are conducted to analyze the perception of a representative sample of the Dutch population (e.g. motives and thresholds behind the adoption process) and logistic regression analyses are used to identify positive predictors for adoption. A segmentation model, based on the adoption or rejection of PV, is used for grouping the respondents. The main added value of the segmentation model is that non-adopters are not seen as a homogeneous group but as two groups: one group of potential adopters and one group of rejecters. Over time it is possible that rejecters become potential adopters and even proceed to adopters. In our view, we offer a novel contribution to the literature through the use of a segmentation model which adds insights in adoption research.

In our analysis, we studied the motivations for adoption for the subgroup of adopters and compared the relevance of different factors for non-adoption for the subgroups of potential adopters and rejecters. The analysis is based on attribute perceptions instead of on objective data. What we find is that that for adopters the costs of adoption are considered affordable, whereas for non-adopters they are viewed as being too high. The differences have to do with adopters valuing the benefits of this technology more than non-adopters. Whether they adopt or not adopt PV panels is just not a matter of costs only, although they certainly are an important element. Unless electricity prices rise significantly and the costs of PV systems decrease substantially, we expect the diffusion of PV systems to be slow.

Furthermore, we find that one of the reasons why potential adopters have not adopted a system so far is that they lack knowledge about PV. The importance of this was revealed through the statistical analysis, where we found that knowledge about PV is a predictor for adoption. (The influence of this variable was revealed through the statistical analysis. The lack of knowledge was not a self-stated reason for non-adoption.) This suggests that better information about solar energy will stimulate adoption. Not only information of the costs and quality aspects is important, also information on social and environmental matters. The importance of the latter and the knowledge of grants and costs were found to be positive predictors for the willingness to adopt. This suggests that two useful strategies to stimulate the diffusion of solar PV are: to reduce the investment costs and increase the knowledge about it. The relative effectiveness of both strategies cannot be determined from our analysis.

Our empirical results show similarities and differences from those found in other empirical literate on adoption of PV. We found that knowledgeability has a positive influence on future adoption which confirms the empirical findings of Labay and Kinnear [23] on the role of knowledge. This suggests that public information about the possibilities and the procedures may be helpful to those interested in adopting solar PV (potential adopters). Similar findings are reported by Kaplan [36] and Jager [38].

The innovativeness of a system, the visual aspect and the ease to install a system are less important motives for people to adopt a system. These results are not in line with the research of Jager [38] and Palm and Tengvard [40], who rated the contribution to a better natural environment as the most important motive for adoption. Palm and Tengvard [40] also indicated the symbolic meaning as an important aspect which is also not in line with our findings. In the study of Jager [19], savings on the electricity bill was not included in the list of motivating factors which is a reason for why it was missed. In the study of Palm and Tengvard (consisting of 20 interviews in Sweden) savings on the electricity bill did not come out as an important issue but perhaps this was not asked. The study does bring out that the high costs of investments act as a barrier, which shows that economic aspects do matter. The economics of PV are a complex issue because it can be viewed in different ways: in terms of the payback period (which has to low enough) or in terms of costs savings on the energy bill. It is an issue for deeper analysis.

We also want to point to weaknesses in our study. A first weakness is that we did not incorporate the influence of opportunity costs and competition with other products in the analysis. A second weakness is that we did not do a deeper analysis of the social environment as a facilitating and constraining factor. Third, the exact influence of effort expectancy behind the adoption and non-adoption of PV could not be determined in this research. Fourth, we were not able to determine the influence of anxiety because it was not included in our questionnaire.

Perhaps the most salient finding is that for some adopters the cost of adoption are acceptable, and for others not. This shows that adoption depends on attribute perceptions. Perception of attributes and the attributes themselves are interrelated. An interesting question is whether government can have a greater effect on adoption decisions by reducing the costs of adoption or by changing the perceptions of existing costs, giving budget constraints and the ability of government to alter cost perception.

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Appendix A

See Table A1.

Table A1

Sample characteristics of Dutch population	Response (%)	CBS (%)
Gender		
Men	53	50
Women	47	50
Age distribution		
21–24	4	8
25–29	9	10
30–34	9	10
35–39	9	12
40–44	13	13
45–49	14	13
50–54	14	12
55–59	15	11
60–65	13	12
Level of education		
Low (primary, vmbo, lbo)	28	29
Middle (havo, vwo, mbo)	41	42
High (hbo, university)	32	29
Spatial distribution in the Netherlands		
Drenthe	3	3
Flevoland	3	2
Friesland	5	4
Gelderland	9	12 5
Groningen	4	4
Limburg	10	7
Noord-Brabant	14	15
Noord-Holland	16	16
Overijssel	6	7
Utrecht	7	7
Zeeland	3	2
Zuid-Holland	20	21

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